

# chapter five

## facility standards

### 5.1 General Guidelines

This section of the report provides design guidelines for the development of bicycle and pedestrian facilities. They are based on the best practices in use throughout the United States, as well as accepted state and national standards for bicycle and pedestrian facilities. The recommended standards in this report meet or exceed national standards found in the AASHTO Guide for the Development of Bicycle Facilities, the Manual on Uniform Traffic Control Devices, and NCDOT Bike Facility Guidelines. As state and national standards are revised, any resulting design discrepancies should favor the updated standards.

### 5.2 Typical Roadway Cross-Sections

All new and reconstructed roadways in the Winston-Salem Urban Area should be designed to accommodate bicycles<sup>1</sup>. While each roadway construction, paving, or striping project must be appropriate for the topography and land use of the corridor, the Winston-Salem/Forsyth County Urban Area Thoroughfare Plan (2002) includes typical roadway cross-sections as guidelines for designing new and reconstructed roads.

Two sets of cross-sections are shown in the Thoroughfare Plan: 1) typical bicycle cross-sections and 2) typical thoroughfare cross-sections. While the bicycle cross-section designs offer some improvements over existing roadway cross-sections for bicycle travel, the City of Winston-Salem should work with NC DOT to consider adopting the revised cross-sections presented in this section. These new cross-sections could provide even more significant increases in bicycle safety and comfort.



**5.2.1 Typical Bicycle Cross-Sections**

One of the objectives of the Thoroughfare Plan is “to provide opportunities for bicycles and pedestrians to safely share the right-of-way with motor vehicles.” National research has shown that bicyclists feel more comfortable and motor vehicles give bicyclists more lateral space when a shoulder or bike lane stripe is provided (Landis, et al. 1996; Harkey, et al. 1998; Hunter, et al. 1999; City of Cambridge, MA 2005). This research is supported by policies in the AASHTO Bicycle Guide (1999)<sup>2</sup>, which states:

*“Bike lanes are intended to delineate the right of way assigned to bicyclists and motorists and to provide for more predictable movements by each. Bike lanes also help to increase the total capacities of highways carrying mixed bicycle and motor vehicle traffic...[Bike lanes may be provided] by reducing the width of vehicular lanes or prohibiting parking...” (p. 8)*

Based on this guidance, five-foot-wide striped bike lanes<sup>3</sup> should be added to all of the typical bicycle cross-sections in the

**Figure 5-1. Proposed Modifications to Typical Bicycle Cross-Sections**

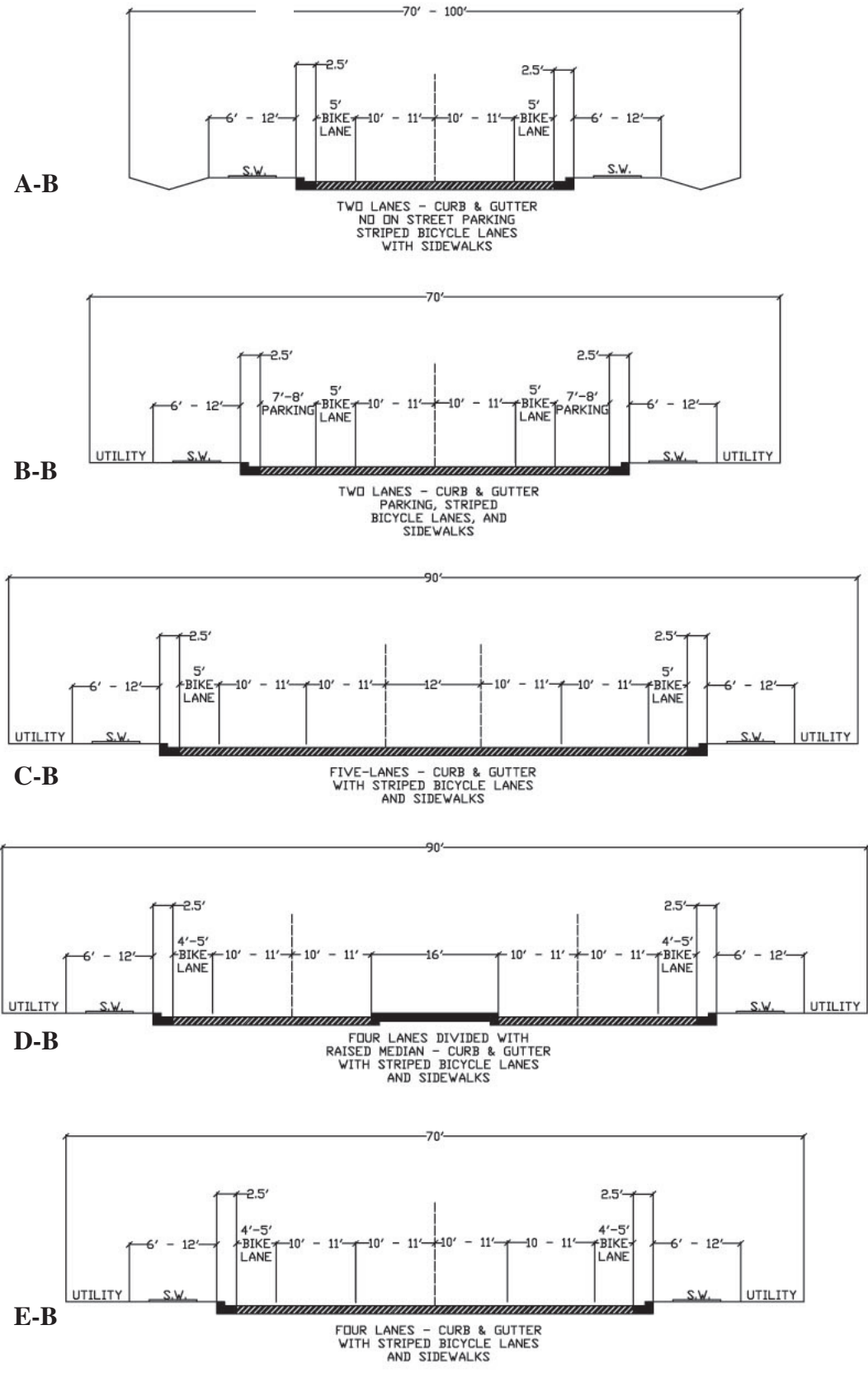
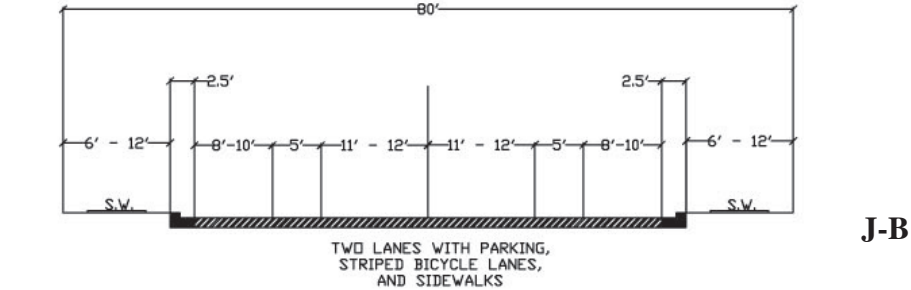
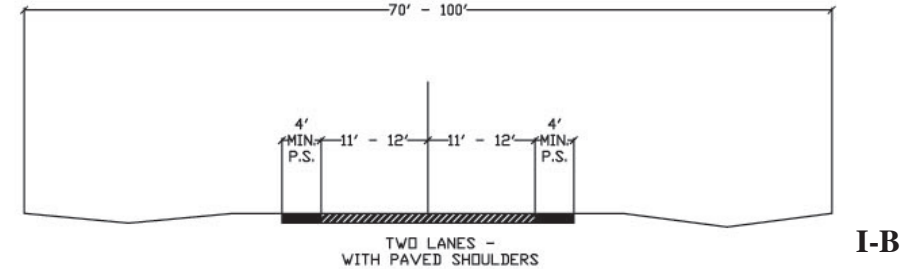
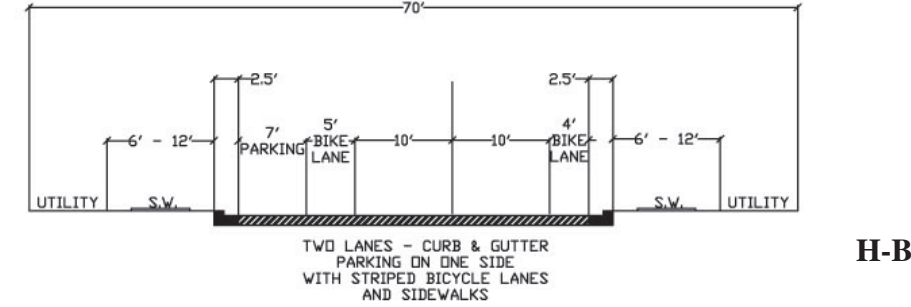
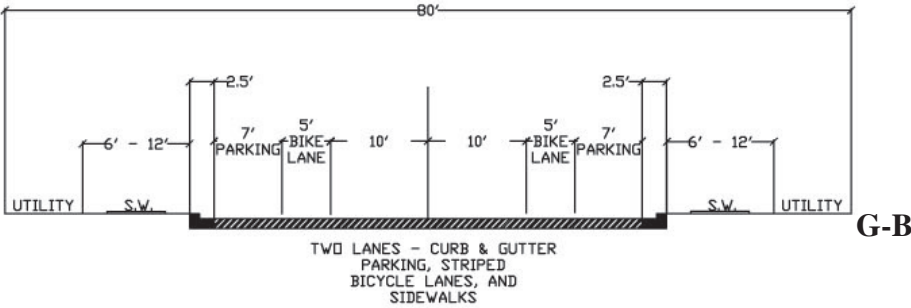
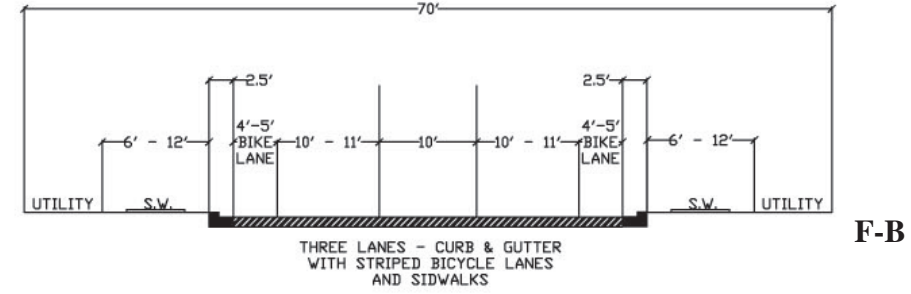


Figure 5.1 (continued)

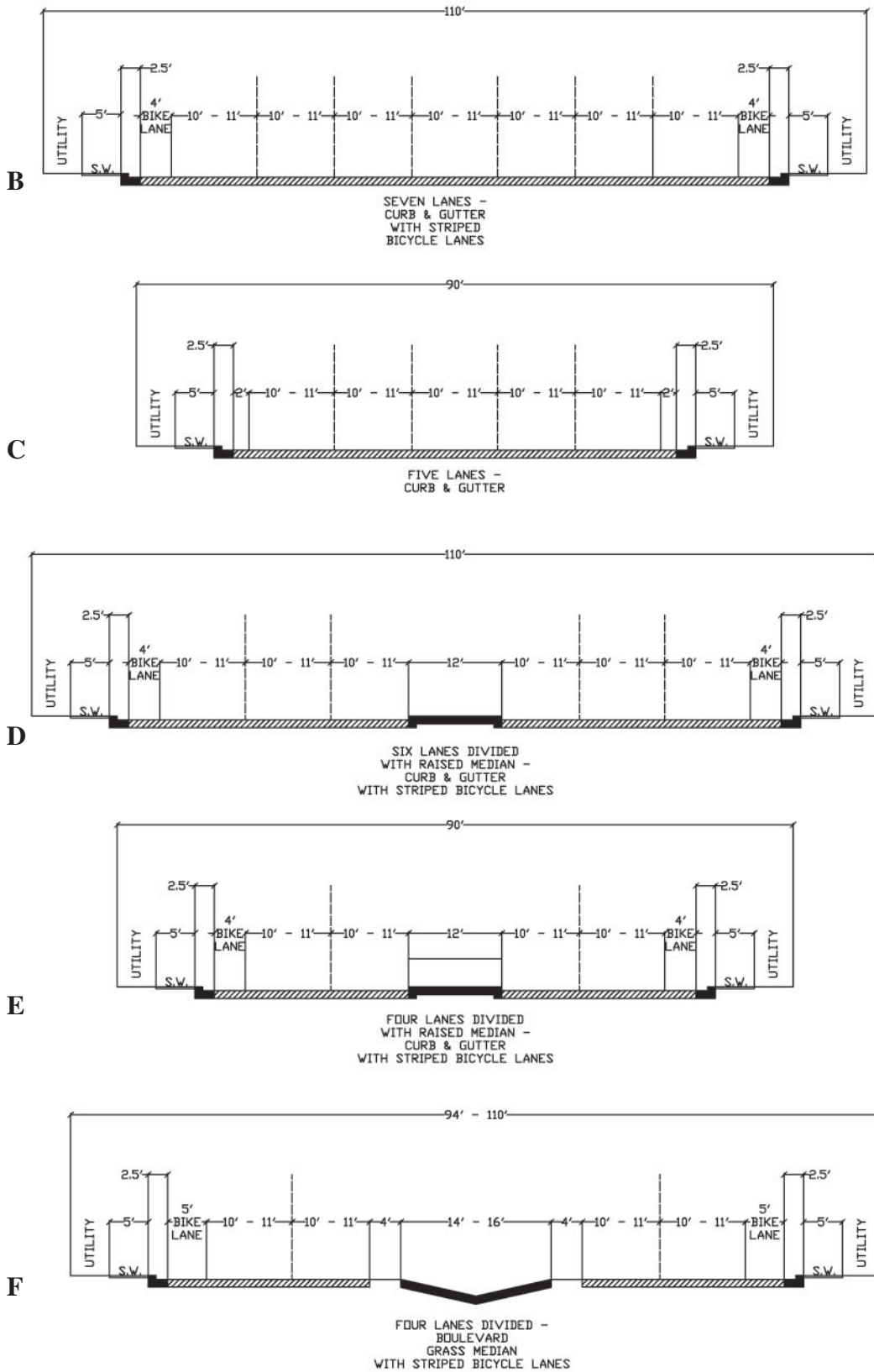


Thoroughfare Plan except for cross sections I-B (a two-lane road with four-foot shoulders) and J-B (a two-lane road with bike lanes). The bicycle lanes can often be accommodated in these cross-sections by reducing the width of the motor vehicle travel lanes by one or two feet. Several of the cross-sections would include the gutter pan width to meet the minimum five-foot bike lane standard. It will be important to ensure that the edge of the pavement is flush with the gutter pan.



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## Figure 5.2 Proposed Modifications to Typical Thoroughfare Cross-Sections



**5.2.2 Typical Thoroughfare Cross-Sections**

The typical thoroughfare cross-sections do not currently include bicycle facilities. While a few of these cross-sections will be used on freeways, most will be used on roadways where bicycles are permitted. In order to provide adequate accommodations for bicyclists, the City of Winston-Salem should work with NC DOT to revise several of these typical thoroughfare cross-sections.

Bike lanes can be incorporated into typical thoroughfare cross-sections B, D, E, F, and M by reducing the width of some lanes and medians (see Figure 5.2)<sup>4</sup>. Bicycle accommodation can also be improved by widening the paved shoulder in cross-section K to four or five feet and by striping a three-and-one-half-foot shoulder (including gutter pan) in cross-section C.

**5.2.3 Applying the Revised Typical Cross-Sections**

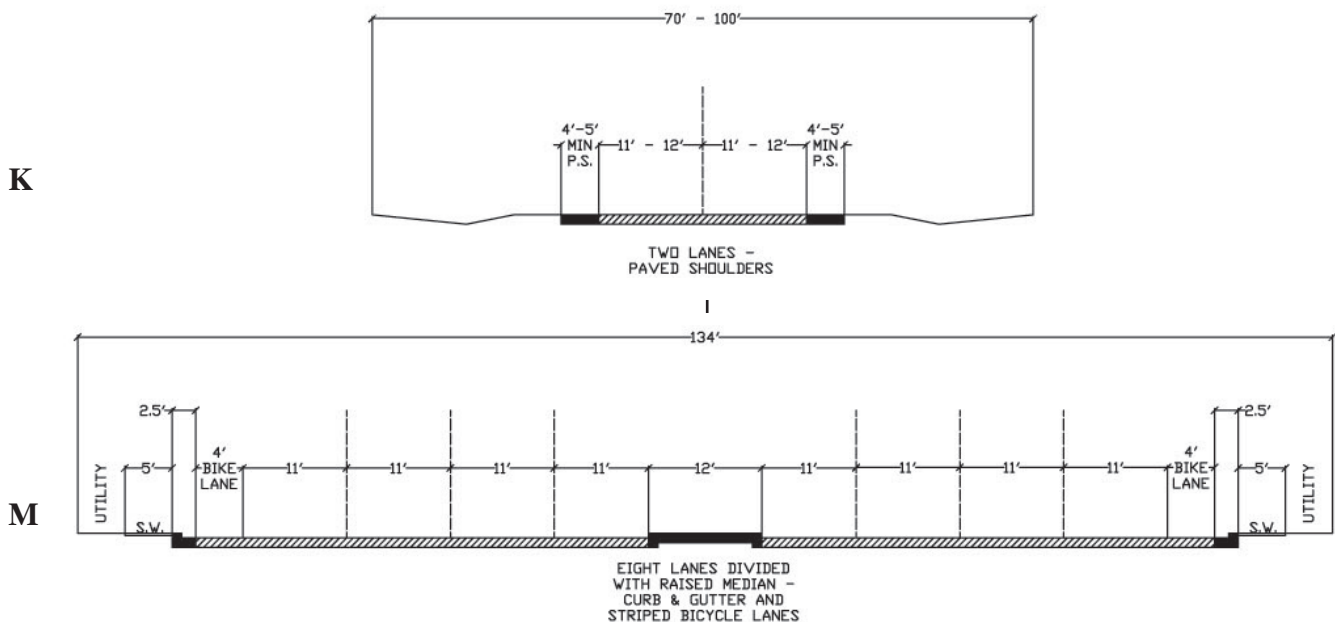
It is important for roadway designers and engineers to consider the unique characteristics of each roadway when choosing the appropriate cross-section. This includes roadway geometrics, functional classification, traffic volume and speed, use by large trucks, and surrounding land use characteristics.

Narrowing the motor vehicle lanes in several of the current bicycle and thoroughfare cross-sections would provide extra space for shoulders and bicycle lanes. In some situations this may also have a desired traffic calming effect, slowing typical motor vehicle traffic by several miles per hour. According to AASHTO’s Guide for Achieving Flexibility in Highway Design (2004), the normal range of design lane width is between nine feet and 12 feet. This guide states:

*“In urban areas and along rural routes that pass through urban settings, narrower lane widths may be appropriate. For such locations, space is limited and lower speeds may be desired. Narrower lane widths for urban streets lessen pedestrian crossing distances, enable the provision for on-street parking and transit stops, and enable the development of left-turn lanes for safety.”*

None of the revised cross-sections would require striping motor vehicle travel lanes narrower than 10 feet, a width that is already used on several roadways in the Winston-Salem Urban Area. Wider lane widths are typically used on roads with higher speeds and volumes and to accommodate wider vehicles, such as trucks and buses.

Figure 5.2 (continued)



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Because traffic characteristics vary across the Winston-Salem Urban Area, some of the lane widths in the revised bicycle cross sections (see Figure 5.1 and Figure 5.2) would only be appropriate for specific types of roadways.

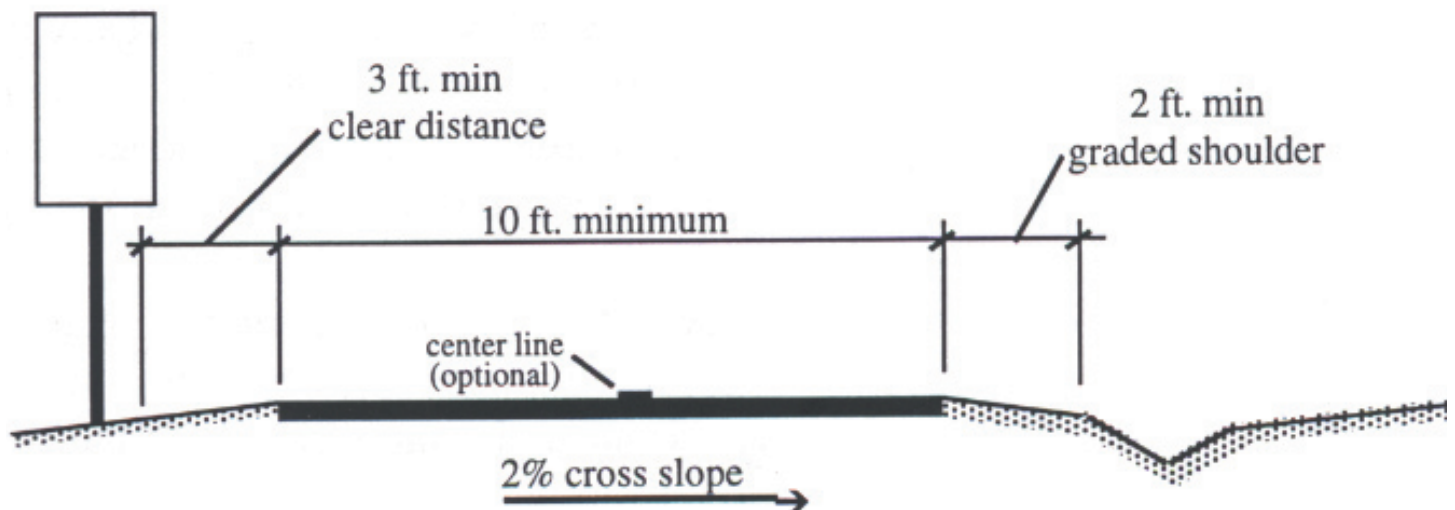
According to the AASHTO Policy on Geometric Design of Highways and Streets (2004, p. 425, 433), minor thoroughfares (collector roadways) can be designed with 10-foot motor vehicle travel lanes. Wider widths should be considered in rural areas if the roadway has high traffic volumes or speeds and considered in urban areas if the roadway carries a large amount of truck traffic.

Major thoroughfares (arterial roadways) are commonly designed with 11-foot travel lanes. However, in urban areas, some major thoroughfares can have narrower lanes. The AASHTO guide states, “Lane widths of 3.0 m [10 ft] may be used in highly restricted areas having little or no truck traffic” (p. 472).

### 5.3 Typical Multi-Use Cross-Sections

Multi-use trails are physically separated from motor vehicle traffic and are built either within an independent right-of-way (e.g. a utility or railroad right-of-way), or along specially acquired easements across private lands. Such trails cater to a variety of different users including cyclists, pedestrians, joggers, roller bladers, and skateboarders. Possible conflicts between these user groups must be considered during the design phase, as cyclists often travel at faster speeds than other users. Multi-use paths can help bicyclists and walkers avoid congested areas, although they sometimes do not provide access to important destinations in congested areas. Off-road trails offer a convenient and pleasant alternative, as well as an opportunity for a novice cyclist to get some riding experience in a less threatening environment. Although multi-use trails usually attract a higher percentage of “B” and “C” cyclists, “A” cyclists can also benefit from their use. (A, B, and C bicycle user types are described in section 5.4.)

Figure 5.3. Typical Multi-Use Trail Cross-Section



The minimum width for a multi-use trail is 10 feet. However, a 12 foot or 14 foot trail is preferred when heavy usage is expected. Appropriate signage should be used to reflect rules and speed limits. Pavement markings should also be used to delineate usage.

## 5.4 Bicycle User Types

Cycling has become a diversified pursuit for millions of Americans. Today, equipment modifications have enabled users to access and ride within a variety of landscapes. The design of bicycle facilities has evolved to keep pace with these changes.

In most states, bicyclists are regarded as vehicle operators and are therefore subject to the laws, rules, and regulations that govern the operation of vehicles within the public rights-of-way and on roadways. Common causes of bicycle/motor vehicle collisions are bicyclists riding the wrong way on the road or riding on the sidewalk.

Bicyclists can be divided into one of the following categories:

**“A” or Expert Cyclist:** These cyclists use their bicycles for transportation and athletic purposes. They are confident in their ability to control their vehicle and ride in a variety of conditions, including along side motor vehicle traffic. They are comfortable using urban, suburban, and rural roads that do not provide shoulders, bike lanes, or other special accommodation for bicycles.

**“B” or Casual Cyclists:** These cyclists use their bicycles for both recreation and transportation purposes. While they will ride within the roadway environment, they generally avoid high speed, heavy traffic roads, unless bike lanes or paved shoulders are provided. They often prefer quiet, less traveled streets and shared-use paths that are separated from the road environment.

**“C” or Inexperienced Cyclists:** Many of these cyclists are children, seniors, or people who have not had

the opportunity to learn safe cycling skills. They are either novice or inexperienced riders that have neither an understanding of traffic laws and regulations nor a good grasp of how to control their vehicle. They may also be dependent on their bicycle as a form of transportation (to friends’ homes, jobs, schools, and recreation venues). This user group is most comfortable on shared-use, off-road paths.

A comprehensive and functional bicycle system caters to the needs of all three cyclist categories.

## 5.5 Bicycle Facility Design Criteria

National standards for the design of bicycle facilities are provided by AASHTO through their “Guide for the Development of Bicycle Facilities” (1999). Nearly 1/3 of the guide is devoted to trail design and the requirements are quite detailed. AASHTO’s guide should be used as a companion to the following sections. Key elements to good bicycle facility design are as follows.

### 5.5.1 Location and Use

A bicycle route is a “suggested way” for a cyclist to get from a point of origin to a destination. They are chosen because they offer preferable degrees of directness, scenery, congestion and traffic speed.

Bicyclists will typically use the most direct route from an origin to a destination. Roadway and pathway systems need to be planned to accommodate this demand. The incorporation of off-road, multi-use paths into the network can help bicyclists and walkers avoid congested urban areas. A drawback of this type of facility is that they sometimes do not provide access to important destinations in the more congested areas.

Facility selection involves a critical analysis of the types of bicyclists that are likely to use the corridor, as well as the current conditions within the corridor. If the candidate route is along an existing or planned roadway, the following factors should be considered.



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- primary design bicyclist
- width of road pavement
- number of travel lanes
- traffic volume
- traffic speed
- sight distance
- presence of truck traffic
- adjacent land uses

### 5.5.2 *Intermodal Connections and Bicycle Parking*

Bicycle racks on buses have proven to be a cost effective way to increase transit ridership and extend the range of service beyond the typical walking distance of transit stops. Once cyclists reach their destination, short-term storage solutions, such as bicycle racks, should be provided as part of streetscape planning. For long-term solutions, bicycle lockers should be installed.

### 5.5.3 *Width*

The minimum preferred width for a bike lane is 5-feet. However, bike lanes can be 4-feet wide if they are adjacent to a gutter pan *and* there is no seam between the street surface and the gutter pan. On roads with parallel parking, bike lanes should be a minimum of 5-feet wide and should be installed adjacent to the motor vehicle lanes, rather than between the parking lane and the curb. Along streets with higher motor vehicle speeds and traffic volumes, wider bike lanes are recommended.

The minimum width for two-directional trails is 10 feet. However, 12-foot and 14-foot widths are preferred where heavy traffic is expected.

If space does not currently exist to create a bicycle lane, other options may be possible, such as reducing lane widths, removing the parking lane on one side of the street, or eliminating a travel lane (given that this does not lower the current level of service for motor vehicles to an unacceptable level), or road widening.

Another option to provide more space for bicyclists is to widen the shoulder. Paved shoulders that are 2- to 3-feet wide can improve conditions and are

recommended in cases where 4-foot widths cannot be achieved. However, shoulders less than 4-feet wide should not be designated as bicycle facilities with signage or on official bicycle route maps. “Share the Road” signs would be acceptable in these locations, as they would serve to warn motorists of the likely presence of bicyclists.

Outside lanes that are wider than the standard 12-foot travel lane can also provide more space for cyclists and easier passing for motorists. Under most conditions, automobiles and bicycles can co-exist in a 14-foot wide curb lane, without the need for the motorist to move into the next adjacent lane.

### 5.5.4 *Speed*

The design speed for a given facility is determined by calculating the maximum speed for the cyclist. Most off-road shared-use paths should have design speeds around 15-20 miles per hour. The design speed for an on-road bicycle facility will share the design speed of an associated roadway.

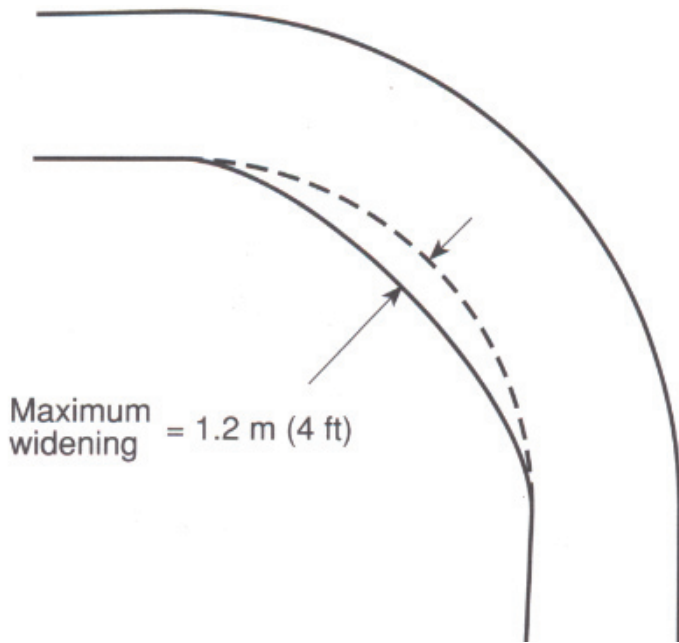
The average speed of a cyclist is 10 miles per hour. However it is not uncommon for cyclist speeds to exceed 20 miles per hour.

### 5.5.5 *Other On-Road Bicycle Facility Design Considerations*

Roadway width and traffic volumes should be taken into account before identifying a bike lane on a roadway. All potential bicycle hazards such as unsafe drainage grates, excessive drop-offs along the gutter pan, and angled railroad crossings must be removed from the roadway or modified.

Rumble strips and rough pavement provide an unrideable surface for bicyclists and should be repaved in order to accommodate bicycle users. As with bicycle lanes, paved shoulders should have the same pavement depth and sub-base as the adjacent roadway and should be regularly swept and kept free of potholes. Areas such as unpaved parking lots, driveways, and unimproved roads may cause debris to enter the bike lane. A solution may be to pave





**Figure 5.4 Minimum Curve Radius**

an adequate distance into the driveways and access roads to reduce the encroachment of debris onto the shoulder.

**5.5.6 Shared-Use Path Design and Alignment**

All bicycle facilities should have a minimum curve radius of 100 feet. When this standard cannot be achieved, warning signs must be used to alert cyclists of the sub-standard curve. Path widening is also recommended for safer turns.

**5.5.6 Shared-Use Path Paving**

Trails designed to serve bicycle transportation purposes should be composed of a hard surface such as asphalt or concrete, and should be designed to withstand the loading requirements of occasional maintenance and emergency vehicles. Installation of a geotextile fabric beneath a layer of aggregate base course can help to maintain the edges of an asphalt trail. It is also important to provide a 2-foot-wide graded shoulder to prevent trail edges from crumbling.

**5.6 Transportation Enhancement Guidelines**

In addition to the previous design criteria, the following guidelines are provided by the NCDOT for applicants wishing to use Transportation Enhancement funds.

- Bike paths must be at least 10’ in width
- Bike paths must have an established design speed
- Bike paths must connect logical, accessible termini
- Bike path surfaces typically include concrete or asphalt; however, other materials may be acceptable (as long as they meet ADA standards)
- Paved shoulders/bike lanes must be at least 4-feet in width and located on both sides of the road
- Bicycle facilities must primarily serve a transportation purpose--not a recreation purpose
- Bicycle designs must be consistent with the NCDOT “roadway standard drawings” and the “standard specifications” publications available from the NCDOT Highway Design Branch, and the “North Carolina Bicycle Facilities Planning and Design Guidelines” publication available from the NCDOT Division of Bicycle and Pedestrian Transportation office.

**5.7 Facility Development Costs**

The tables at the end of Appendix D (section D.5) contain information in response to Council’s request for cost estimates on the Bicycle Plan’s Recommendations. A sample of cost estimates based on the 2000 Bond Referendum road projects has been included. Cost estimates are only provided for projects within the city limits.

A primary goal of the Bicycle Plan is to guide the Winston-Salem Urban Area in the creation of a first-class bicycle network by coordinating the recommendations in the plan with state and local road improvements, such as repavings, widenings, and extensions.



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Incidental roadway improvement projects, like bike facilities, that are added to a roadway reconstruction project and are funded with state and federal dollars are built at no cost to the locality<sup>5</sup>. The cost of the bicycle facility is rolled into the overall cost of the project, therefore the locality only loses the opportunity to gain a bicycle facility at *no cost* if it fails to include the request for the bicycle improvement along with the roadway improvement.

In locally funded projects, NCDOT generally found that the addition of the bicycle facility is <1% of the total cost<sup>5</sup>. Typically, the addition does not change the amount of ROW that NCDOT purchases, nor are mobilization costs any higher. The negligible costs for the additional width lie in the additional soil grading that may be needed, and additional materials. (See section D.5 for sample project costs)

Additionally, Shared-Use Paths (Greenways) make up 21% of the total plan cost. These recommended greenways come from the proposed greenways identified in the 2015 Winston-Salem And Forsyth County Greenway Plan adopted in 2003. Although the plan provides cost estimates for some of the Proposed Priority trails, it does not provide estimates for all of the proposed trails. One of the four Shared-Used Paths in the Top Priority Road Improvements currently has funding for construction and is in the design phase. The other three all have funding identified for feasibility studies in the 2006-2012 Draft Transportation Improvement Program (TIP).

Finally, the tables in section D.5 display that the average cost per mile to construct 315 miles of the recommended bicycle facilities, with the exception of signs and the unknown facilities, is approximately \$393,700. This approximation is compared to the average cost per mile to construct 6 miles of Bond projects at \$4,397,000.

### Notes

<sup>1</sup> With the exception of freeways/expressways where bicycles are prohibited. In these situations, bicycles should be accommodated on a shared-use path or other parallel route nearby.

<sup>2</sup> In addition, AASHTO's *Guide for Achieving Flexibility in Highway Design* (2004) states, "Paving part or all of the shoulder...helps reduce crash rates...and helps to facilitate use of the road by bicyclists. Shoulder paving also reduces maintenance requirements...Where a 'full width' shoulder cannot be achieved, the designer should strive to provide as wide a shoulder as possible that meets functional requirements" (p. 66).

<sup>3</sup> Recommended bicycle cross-sections D-B, E-B, F-B and H-B have bike lanes that use 4-feet of pavement width. The AASHTO Bicycle Guide (1999) allows gutter pan width to be included to meet the 5-foot minimum bike lane width standard as long as the gutter pan is flush with the pavement surface.

<sup>4</sup> Recommended typical thoroughfare cross-sections B, D, E, and M have bike lanes that are 4-feet wide. Though the preferred width for bike lanes is 5 feet, the AASHTO Bicycle Guide (1999) allows this narrower width if the bike lane is adjacent to a gutter pan that is flush with the pavement surface.

### References

<sup>5</sup> Norman, Tom. *NCDOT Bicycle and Pedestrian Division*. (2005).

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